(12) UK Patent Application (19) GB (11) 2 041 409 A

(21) Application No 8004738
(22) Date of filing
13 Feb 1980
(30) Priority data
(31) 7904476
(32) 14 Feb 1979
(33) France (FR)
(43) Application published
10 Sep 1980
(51) INT CL^3 C25C 3/16
(52) Domestic classification
C7B 121 215 283 AB
(56) Documents cited
GB 2001344A
GB 1551887
GB 1551160
(58) Field of search
C7B

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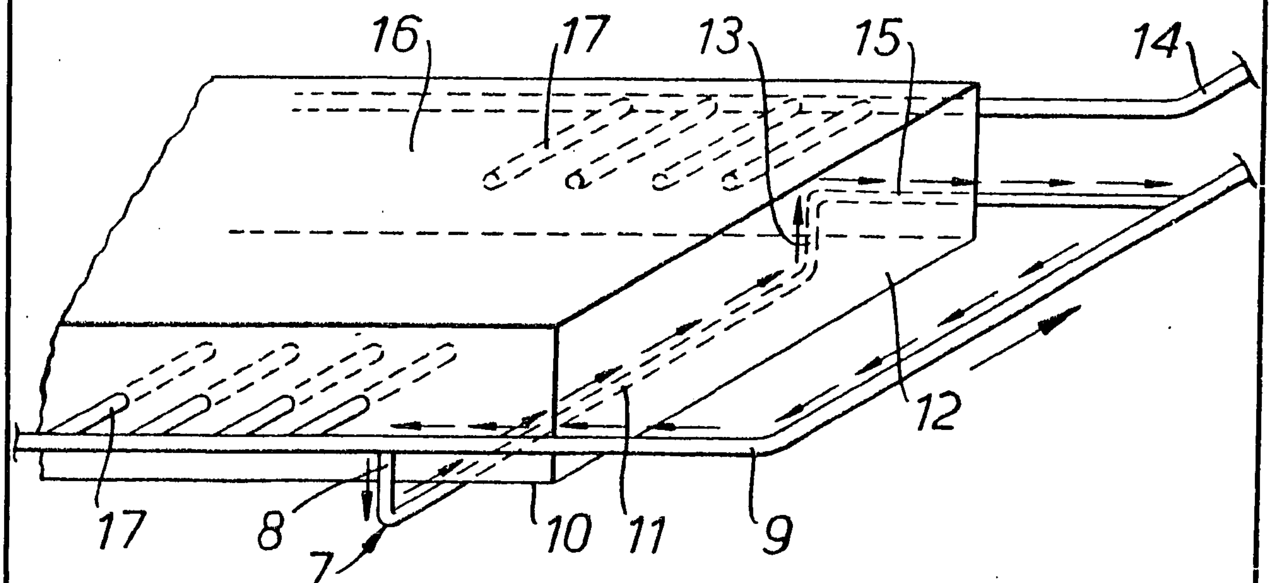
(54) **Processes for the symmetrisation of the vertical component of the magnetic field of electrolysis tanks**

(57) Below each tank head is disposed a compensation loop (8, 11, 13, 15) for producing a supplementary vertical magnetic field of the tank on its short side, and of opposite direction, and at least a fraction of the current which passes through the upstream negative collector (9) passes through each of said loops. The tanks can be high-intensity igneous electrolysis tanks for the production of aluminium.

FIG. 3.



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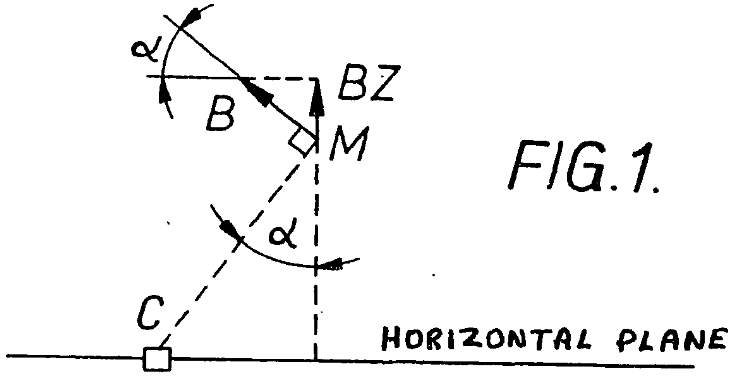


FIG.1.

FIG.2.

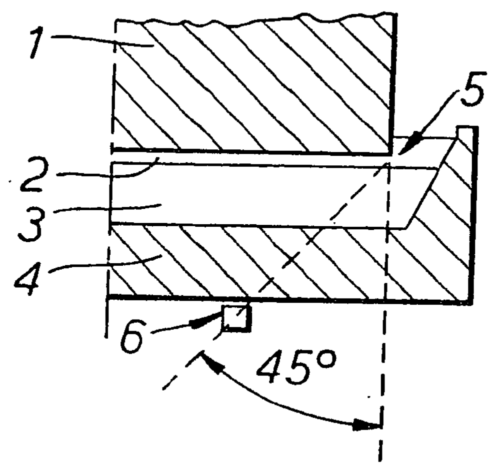


FIG.3.

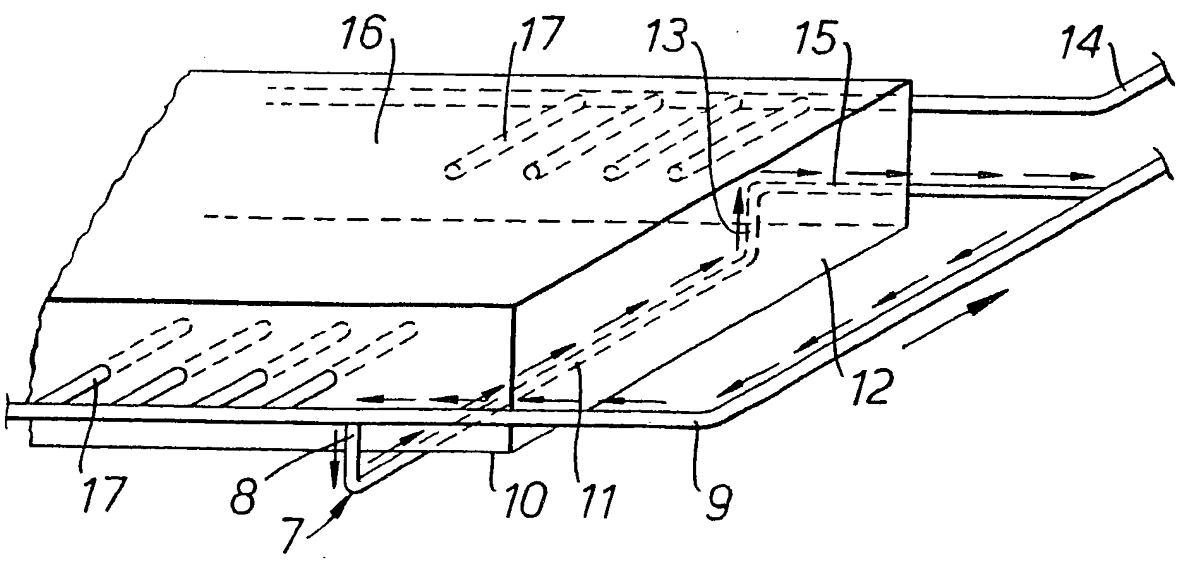
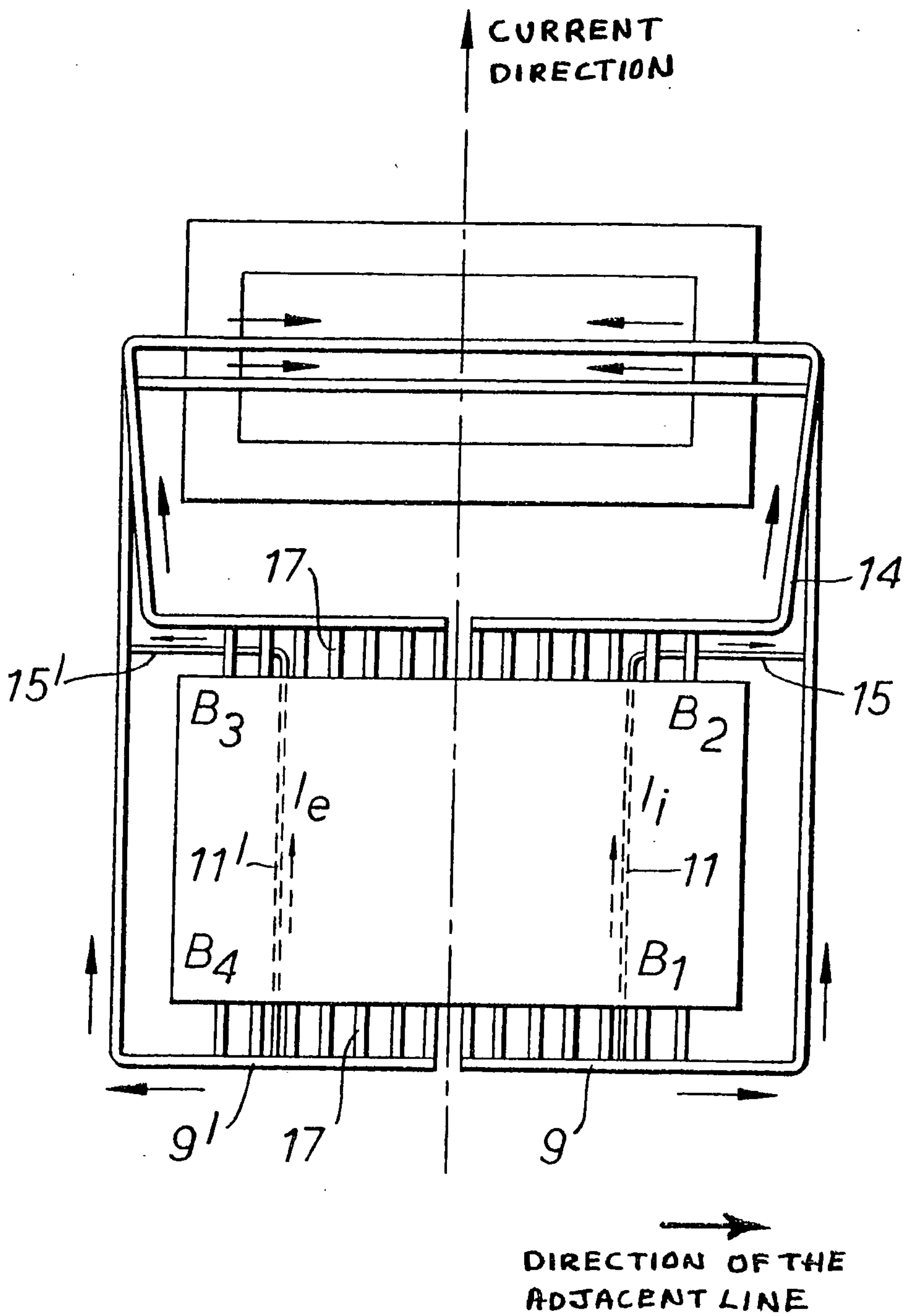


FIG. 4.


CURRENT DIRECTION
17
14
15'
15
B_3
B_2
I_e
I_i
11'
11
B_4
B_1
9'
17
9
DIRECTION OF THE ADJACENT LINE

SPECIFICATION

Processes for the symmetrisation of the vertical component of the magnetic field of electrolysis tanks

The present invention concerns processes for the symmetrisation of the vertical component of the magnetic field in electrolysis tanks which are connected in series and disposed transversely with respect to the axis of the series. Such tanks may be used for the production of aluminium by the electrolysis of alumina dissolved in molten cryolite.

For proper comprehension of the following description, it will be recalled that the industrial production of aluminium is by means of igneous electrolysis, in high-intensity igneous electrolysis tanks which are electrically connected in series, of a solution of alumina in cryolite which is raised to a temperature of the order of from 950 to 1000°C by the Joule effect of the current passing through the tank.

Each tank comprises a rectangular, crucible-forming cathode, the bottom of which is formed by blocks of carbon which are sealed on to steel bars, referred to as cathodic bars, which serve to carry the current from the cathode to the anodes of the following tank.

The anodes, which are also of carbon, are sealed on to rods which are tightly clamped on to bars of aluminium, referred to anodic bars, which are fixed on a superstructure which overhangs the crucible configuration of the tank. The anodic bars are connected by aluminium conductors, referred to as 'risers', to the cathodic bars of the preceding tank.

Disposed between the anodes and the cathode is the electrolysis bath, that is to say, the solution of alumina in cryolite. The aluminium produced is deposited on the cathode, a reserve store of aluminium being constantly maintained at the bottom of the cathodic crucible.

The crucible being of a rectangular configuration, the anodic bars for supporting the anode are generally parallel to the long sides of the crucible, while the cathodic bars are parallel to the shorter sides of the crucible, referred to as the tank heads.

The tanks are arranged in lines, lengthwise or crosswise, according to whether their long side or their short side is parallel to the axis of the line. The tanks are electrically connected in series, with the ends of the series being connected to the positive and negative outputs of an electrical rectifying and regulating sub-station. Each series of tanks comprises a certain number of lines connected in series, the number of lines preferably being an even number in order to avoid conductors being of needless lengths.

The electric current which flows through the different conductors (electrolyte, liquid metal, anodes, cathodes, and connecting conductors) produces substantial magnetic fields. In the electrolysis bath and in the molten metal contained in the crucible, the magnetic fields produced induce forces referred to as Laplace forces which, by virtue of the movements which they cause, are harmful to satisfactory operation of the tank. The design of the tank and its connecting conductors is such that the magnetic fields produced by the different parts of the tank and the connecting conductors compensate each other; this therefore results in a tank whose plane of symmetry is the vertical plane which is parallel to the line of tanks and which passes through the centre of the crucible.

However, the tanks are also subjected to interference magnetic fields originating from the adjacent line or lines.

In the following, the terms 'upstream' and 'downstream' are used with respect to the general direction of the electric current in the line of tanks in question. The term 'adjacent line' is used to denote the line which is closest to the line in question, and the term 'field of the adjacent line' is used to denote the resultant of the fields of all the lines of tanks, other than the line in question.

An embodiment of the invention described hereinbelow is designed to provide an arrangement including a tank wherein the anodic system is supplied by means of current feed means disposed on the short sides of the tank and wherein the arrangement of the inter-tank conductors is such as to provide excellent symmetry in respect of the vertical magnetic field, in accordance with the following rule:

the absolute value of the vertical field component Bz is the same in the four angles or corners of the tank; and

the sign of Bz is alternatively positive and negative when going from one angle of the tank to the other around the perimeter thereof.

This result is achieved:

(a) taking account of the magnetic field produced by the adjacent lines of tanks; and

(b) taking account of the modification in the magnetic field due to the presence of ferromagnetic members disposed in the vicinity of the tank.

Bz denotes the component of the magnetic field along the vertical axis Oz, in a reference trirectangle trihedron whose axis Ox is parallel to the axis of the series in the direction of the current, the point O being fixed at the centre of the cathodic plane.

French Patent No. 2 333 060 and Certificate of Addition No. 2 343 826 thereto disclose means which seek to compensate for the magnetic field produced by the adjacent lines of tanks, by placing a current loop circuit below the outer head, that is to say, below the shorter side of the tank, being the side

which is most remote from the closest line. The arrangement used comprises diverting a part of he current which passes around the outside head of the tank, by passing it through a conductor disposed below the tank.

According to the invention there is provided a process for the symmetrisation of the vertical component of the magnetic field of electrolysis tanks which are connected in series and disposed transversely with respect to the axis of the series, that is to say, to cause the vertical magnetic field to be of substantially the same absolute value in the four angles of the tank with signs which are alternatively positive and negative when following the perimeter of the tank, wherein the distribution of current in conductors for supplying an anode of a downstream tank from a cathode of an adjacent upstream tank is modified in such a way as to superimpose on the tank two electrical loops producing a supplementary vertical magnetic field substantially equal to the mean vertical magnetic field of the tank on its short side and of opposite direction, the electrical loops being dispsoed below each of the short sides of the tank.

Preferably, a current loop is formed beneath each tank short side or head by passing through a supplementary conductor at least a fraction of the current which passes through an upstream negative collector, said supplementary conductor rejoining the same upstream collector, passing along the long downstream side of the tank.

The supplementary conductors are preferably positioned as high as possible beneath the tank, horizontally and parallel to the short sides of the tank, and in such a way that the planes through the inner and outer conductor and through the inner edge of the anode on the inner and outer short sides respectively form an angle of substantially 45° to the vertical.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which:

Figures 1 and 2 are diagrammatic views of the position of a compensation conductor beneath the heads of an electrolysis tank;

Figure 3 shows the real geometrical arrangement of a compensation loop circuit beneath one of the heads of the tank; and

Figure 4 is a diagrammatic plan view of the positions of the conductors forming connections between two successive tanks and the position of the compensation loop circuits below the heads of one of the tanks (the upstream tank).

In order to carry the invention into effect, it is first necessary to determine the current intensities Ii and Ie in the compensation loops.

The vertical magnetic field is calculated, in each of the angles of the tank (let the following apply (Fig. 3)):

Bz_1 in the inner upstream angle
Bz_2 in the inner downstream angle
Bz_3 in the outer downstream angle
Bz_4 in the outer upstream angle

The expressions upstream/downstream are used with respect to the general direction of the current in the line of tanks. Calculation of these fields is effected, taking into account the magnetic field produced by the adjacent lines and the action on the field of the ferromagnetic masses disposed in the vicinity of the tank.

The following two equations are then set out:

$$\begin{aligned} Bz_1 + Bz_2 &= 0 \\ Bz_3 + Bz_4 &= 0 \end{aligned} \qquad (1)$$

The equations (1) are linear in respect of Ii and Ie (the magnetic field being proportional to intensity) and therefore make it possible to determine Ii and Ie.

Now, it is known that, when there are no adjacent lines, the vertical component Bz'_1, Bz'_2, Bz'_3, Bz'_4, of the magnetic field in the four angles of the tank is antisymmetrical in respect of y, the tank by its construction being symmetrical with respect to the plane xOz; we therefore have:

$$Bz'_1 = -Bz'_4$$
$$Bz'_2 = -Bz'_3$$

The vertical field produced by the adjacent lines on the one hand and by the magnetic loop circuits on the other hand is practically independent of the abscissa x, that is to say, it is of a constant value bz over the whole of the inner short side and a constant value bz' over the whole of the outer side.

We therefore have:

$$Bz_1 = Bz'_1 + bz$$
$$Bz_2 = Bz'_2 + bz$$
$$Bz_3 = Bz'_3 + bz' = -Bz'_2 + bz'$$
$$Bz_4 = Bz'_4 + bz' = -Bz'_1 + bz'$$

Taking into account Equations (1), we have:

$$bz = -bz' = -\frac{Bz'_1 + Bz'_2}{2}$$

$$Bz_1 = \frac{Bz'_1 - Bz'_2}{2}$$

$$Bz_2 = \frac{Bz'_2 - Bz'_1}{2}$$

$$Bz_3 = \frac{Bz'_1 - Bz'_2}{2}$$

$$Bz_4 = \frac{Bz'_2 - Bz'_2}{2}$$

and:

$$Bz_1 = -Bz_2 = Bz_3 = -Bz_4 \qquad (2)$$

The aim being to modify, by improving, the vertical magnetic field on the short side of the tank, the conductor passing below the tank will be so positioned that it has maximum action on that region.

Referring to Fig. 1, C represents a section of a compensation conductor, in end view; M represents the point at which the magnetic field to be compensated is at its most intense; and α is the angle made by the plane containing the compensation conductor C and the point M, with the vertical. If the strength or intensity of the current in the conductor C is denoted by I, the magnetic field B at point M is of the following value:

$$B = \frac{2I}{h} \cos \alpha$$

If Bz is used to denote the vertical component of the field at point M, we have:

$$Bz = B.\sin \alpha$$

$$= \frac{I}{h} \times 2 \cos \alpha \sin \alpha$$

$$= \frac{I}{h} \sin 2\alpha$$

Bz is at a maximum for $\sin 2\alpha = 1$, and therefore when $\alpha = 45°$.

The compensation conductor is therefore desirably positioned, as shown in Fig. 2, in such a way that the plane defined by the conductor and by the outer angle of the anode is at an angle of substantially 45° to the vertical.

In Fig. 2, which is a diagrammatic view of a vertical section through the outer head of an electrolysis cell, reference numeral 1 denotes the anode, reference numeral 2 denotes the molten electrolyte, reference number 3 denotes the layer of liquid aluminium, reference numeral 4 denotes the cathodic block, reference numeral 5 denotes the lower angle of the anode in the vicinity of which the vertical magnetic field to be compensated is at its maximum, and reference numeral 6 denotes the compensation conductor.

Fig. 3 is a diagrammatic perspective view of a head of an electrolysis cell and shows the position and the line of the compensation conductor (7), which comprises: a down portion 8 from an outer upstream negative conductor or collector 9 to the level of the bottom of the tank 10; a horizontal portion 11 beneath the tank parallel to its short side 12; an up portion 13 to the level of the outer downstream negative collector 14 disposed between the latter and the body of the tank; and a return portion 15 parallel to the long side 16 of the tank, to rejoin the outer upstream collector 9. The arrowed dotted line indicates how the electric loop for generating the compensation field is formed. The cathodic bars are denoted by reference 17. A loop which is identical and symmetrical with respect to the axis of the series is disposed on the other head end of the tank, as shown in Fig. 4.

The above-indicated arrangement is used on a series of 90 kA tanks, with 14 m distance between lines of tanks, and, from equations (1), the following calculations are made:

$Ii = 9$ kA (approximately); and
$Ie = 22.5$ kA (approximately).

The following vertical magnetic fields are measured on these tanks, in the angles:

$Bz_1 = 31$ Gauss
$Bz_2 = -40$ Gauss
$Bz_3 = 30$ Gauss
$Bz_4 = -40$ Gauss

Symmetry is therefore achieved in an entirely satisfactory manner.

By comparison, the following vertical magnetic fields, in the angles, were measured on a series of tanks which were identical but not compensated:

$Bz_1 = 55$ Gauss
$Bz_2 = -25$ Gauss
$Bz_3 = 15$ Gauss
$Bz_4 = -75$ Gauss

A lack of balance of this kind affects proper operation of the tanks and results in an unsatisfactory Faraday output.

CLAIMS

1. A process for the symmetrisation of the vertical component of the magnetic field of electrolysis tanks which are connected in series and disposed transversely with respect to the axis of the series, that is to say, to cause the vertical magnetic field to be of substantially the same absolute value in the four angles of the tank with signs which are alternatively positive and negative when following the perimeter of the tank, wherein the distribution of current in conductors for supplying an anode of a downstream tank from a cathode of an adjacent upstream tank is modified in such a way as to superimpose on the tank two electrical loops producing a supplementary vertical magnetic field substantially equal to the mean vertical magnetic field of the tank on its short side and of opposite direction, the electrical loops being disposed below each of the short sides of the tank.

2. A process according to claim 1, wherein a current loop is formed beneath each tank short side or head by passing through a supplementary conductor at least a fraction of the current which passes through an upstream negative collector, said supplementary conductor rejoining the same up-

stream collector, passing along the long downstream side of the tank.

3. A process according to claim 2, wherein the supplementary conductors are positioned as high as possible below the tank, horizontally and parallel to the short sides of the tank, in such a way that the planes passing through the inner and outer conductor and the inner edge of the anode on the inner and outer short sides respectively form an angle of substantially 45° to the vertical.

4. A process for the symmetrisation of the vertical component of the magnetic field of electrolysis tanks which are connected in series and disposed transversely with respect to the axis of the series, the process being substantially as herein described with reference to the accompanying drawings.

5. An arrangement of electrolysis tanks in which the vertical component of the magnetic field has been symmetrised by a process according to any one of the preceding claims.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1980.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.